Astronomy in Focus, Volume 1
XXXth IAU General Assembly, August 2018
Teresa Lago, ed.

DOI: 00.0000/X000000000000000X

Terra-Astronomy – Understanding historical observations to study transient phenomena

Ralph Neuhäuser[1], **Dagmar L. Neuhäuser**[2] **and Thomas Posch**[3]

[1]Astrophysical Institute, University of Jena, 07745 Jena, Germany
email: ralph.neuhaeuser@uni-jena.de

[2]Independent scholar, Merano, Italy & Jena, Germany

[3]Department of Astrophysics, University of Vienna, 1180 Vienna, Austria

Abstract. We give an overview of Focus Meeting 5 on the new field of Terra-Astronomy.

Keywords. solar activity, supernovae, novae, comets, eclipses, history of astronomy

---

Focus Meeting 5. During the General Assembly 2018 of the International Astronomical Union in Vienna, Austria, Focus Meeting 5 (FM5) took place about *Understanding historical observations to study transient phenomena* (Terra-Astronomy).
Scientific Organizing Committee: S.-H. Ahn, A. Ankay, D. Banerjee, J. Evans, L. Fletcher, R. Gautschy, D.L. Neuhäuser, R. Neuhäuser (co-chair), T. Posch (co-chair), B. Schaefer, J. Steele, F.R. Stephenson, J. Vaquero, N. Vogt, M. Werner, H.R.G. Yazdi. See www.astro.uni-jena.de/IAU for program and details. Editors of the proceedings for FM5 were Ralph Neuhäuser, Elizabeth Griffin, and Thomas Posch. FM5 covered 11 reviews, 16 contributed talks, and 18 poster papers, only some of them could be included here.

What is Terra-Astronomy? The study of historical observations motivated by contemporary astrophysical questions is valuable for different fields in astronomy. Terra-Astronomy concentrates on those transient phenomena, for which some aspects of the their transient nature are not yet fully understood. Terra-Astronomy uses *terrestrial* archives: historical archives (text records from previous centuries) and natural archives (e.g. ^{14}C in trees and ^{10}Be in polar ice as solar activity proxies); and Terra-Astronomy studies phenomena which potentially can affect *Terra*:
(1) While we can study solar activity in great detail with satellites only since a few decades (too short for secular changes), telescopic sunspot observations are available for four centuries (Clette et al., this issue) – yet, polar lights and sunspots were recorded since more than two millennia ago. While solar activity can also be studied with radioisotopes (solar wind being inversely proportional to cosmic-ray influx), they depend on the Earth magnetic field, whose reconstruction is also uncertain.
(2) Solar and lunar eclipses (and other conjunctions) which were recorded with a precise location (and being dated) are used to study secular variations in the Earth rotation and acceleration of the Moon (Stephenson et al., this issue).
(3) Historical observations of comets (e.g., Zolotova et al., this issue) and meteor streams facilitate orbit solutions and the study of their origin and dynamics.
(4) Pre-telescopic observations of novae and supernovae enable detailed studies of their remnants (Pagnotta et al. and Cosci, this issue); age and celestial location are well-known from the historical records, some light curves could be derived; historical supernovae are the most nearby stellar explosions, so that deep follow-up observations can reveal possible former donor stars (SN Ia), other previous companions, and neutron stars (SN II). New records on historical supernovae written in Arabic were uncovered recently (e.g. R.

Neuhäuser et al. 2016), so that progress is possible also in this field – for a precise dating on the Muslim lunar calendar, one needs to know when the lunar crescent was first visible at that time and location (Gautschy & Thomann, this issue).
(5) More transient phenomena were possibly observed in history, such as meteoritic impacts on Earth or Moon, changes in brightness or color of stars, or optical transients in gamma-ray bursts; some may also be detectable on photographic plates.
Previous works have shown that applied historical astronomy can be very useful for astrophysics. The recently measured ^{14}C variation around AD 775 triggered a new interest in historical observations, so that, e.g., several teams have studied northern lights observed at around that time to reconstruct the solar activity state and to evaluate the possibility of a solar super-flare (e.g., R. Neuhäuser & D.L. Neuhäuser 2015). This Focus Meeting also covered observations after the invention of the telescope: e.g., we discussed telescopic (and naked-eye) sunspots and aurorae until around AD 1715, the end of the Maunder Minimum, as well as the Carrington flare in AD 1859.

Understanding historical records. In all such cases, it is essential to correctly understand the historical reports, which are texts in old to ancient languages: translation may work best in collaboration between astronomers and scholars of languages (articles by Chapman, Hunger, and Shylaja, this issue). Available competence in the field of History of Astronomy and cultural knowledge can significantly advance the correct understanding of historical observations. The widespread interpretation of transient phenomena as problematic omina often had a deep cultural impact.

E.g., most recently, a *red cross* observed in England around AD 775 was interpreted as absorbed supernova, as airglow after a gamma-ray burst, as aurora borealis indicating a solar activity maximum (all in connection to a strong ^{14}C variation around AD 775), and as an unrelated halo display – indeed, there are many meteorological phenomena recorded in, e.g., aurora catalogs (see D.L. Neuhäuser & R. Neuhäuser 2015).

We put forward eight recommendations:

• Historical records must not be used as quarry: we have to approach the problem unbiased, we have to be aware of our modern interests. E.g., what did our *ancestors* see, when they reported a *red cross* in their chronicle ? They wrote down, what was important for them, and maybe also to preserve it for us.

• Any such work should be based on critical editions, which contain variants of the different copies, dating corrections, sources, history of transmission etc.

• Any translation is an interpretation, and the meaning of words can evolve.

• No text without context – especially, it is not sufficient to search just digitally for a certain keyword in large text corpora; digital searches have to be conducted carefully (D.L. Neuhäuser et al. 2018).

• Consider author's intention and the ideological background – the zeitgeist: chronicles reflect the connection between (celestial) signs and following (terrestrial) events – understanding of the signs as portents.

• Today's terminology is defined by physics – historical descriptions are pheno-typical: a phenomenon can be, e.g., rainbow-like, but it is not necessarily a *rainbow* in our sense.

• Criteria help to identify the likely true physical character of the phenomena (e.g. polar lights, halo effects, meteor showers, comets), historical records provide information on up to five criteria: (i) timing, (ii) direction, (iii) color and form, (iv) dynamics/changes, and (v) duration/repetition, see D.L. Neuhäuser et al. (2018).

• One should provide references of previous catalogs considering the discussed events and a list of rejected false-positives.

Working on astronomical problems by interpreting historical texts is different in methodology from other fields of astrophysics.

Methodological and epistemological aspects. Terra-Astronomy is a study of historical astronomical events with respect to questions relevant to current astrophysics. It needs to use specific methods of the humanities (e.g., a hermeneutical approach to ancient texts), but also shares its methods and goals with the natural sciences.

Astronomy in general, much more so than, e.g., theoretical physics, includes elaborate studies of individual objects. But are we interested in such remote individual objects for their own sake – or rather in the context of general laws (e.g., those on the evolution of the solar system)? We also discussed epistemological aspects of Terra-Astronomy, where we would deduce general knowledge from individual events.

Terra-Astronomy deals both with *nature* and with *history*: our primary data are typically historical records – hence, the exceptional role of *understanding of texts.* The final purpose of our studies is typically the refinement of general laws of nature. In Terra-Astronomy, as in Kant and Rickert, *historical* means a *past event*, while *something regarded as a unique individual* can be termed *historic*, in German both *historisch.* Any event studied in Terra-Astronomy includes *facts in their uniqueness and individuality.* Thereby, it has the potential to expand the scientist's epistemological perspective.

As synthesis of the prototypical natural-scientific and the *individualising* approach to reality, *Astronomy is one of those disciplines in which the generalising way and the individualising way of concept formation are most intimately connected to each other* (Rickert 1986). The case to be made here is: this characteristic feature of astronomy is even more characteristic of Terra-Astronomy, it is indeed one of the defining features of the latter. It is the reason for the fact that Terra-Astronomy is truly trans-disciplinary.

Further aspects. This newly emerging field has a strong potential also in education and outreach (e.g., Zotti & Wolf, this issue), as the extraction of celestial observations from local chronicles can indeed be done by, e.g., school students and amateur historians, e.g. in a world-wide Citizen Science project; such a project can raise the public awareness for the variety of celestial phenomena and their relevance for Earth. Studying solar activity proxies is also a timely service to humanity, as the Sun currently shows a weak Schwabe cycle, so that a new Grand Minimum may be starting.

The vast and disparate amount of historical observations also calls for a world-wide and homogeneous catalogue, also implementing oral reports and drawings – a call to save this valuable heritage, so that we can understand the past and utilize it for solving forefront astrophysical problems. Resolution B3 recommends *that a concerted effort be made to ensure the preservation, digitization, and scientific exploration of all of astronomy's historical data, both analogue and primitive digital, and associated records.* Some celestial phenomena are also relevant for other natural science fields, e.g. atmospheric darkenings for geophysics (volcanos) and meteorology. Absolute dating of celestial observations (e.g. with comet orbits, eclipses, conjunctions) advances historical chronology. Many celestial phenomena were already found in annals, more old texts become available in scientific editions and are translated to modern languages, so that it is possible to advance the study of historical observations to more cultures (e.g. Arabic, Indian) and earlier epochs.

References

Neuhäuser, D.L. & Neuhäuser, R. 2015, *AN*, 336, 913
Neuhäuser, D.L., Neuhäuser, R., Harrak, A. 2018, *JCSSS*, 18, 67
Neuhäuser, R. & Neuhäuser, D.L. 2015, *AN*, 336, 225
Neuhäuser, R., Rada, W., Kunitzsch, P., Neuhäuser, D.L. 2016, *JHA*, 47, 359
Neuhäuser, D.L., Neuhäuser, R., Chapman, J. 2018, *AN*, 339, 10
Rickert, H. 1986, The limits of concept formation in natural science, CUP Cambridge